Space Weather Technical Forecast

Issued on Wednesday, 08 February 2023 at 13:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-flares (R1/R2 Radio Blackouts) likely
Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with five M-flares observed. Peak flare was an impulsive M6.3 at 07/2307 UTC from AR3213 near the north centre disc. This region continues to develop, and has a beta-gamma-delta field, although the delta spots are very small and difficult to see. A further large region is present in the north disc, AR3214, however this is a simple east-west aligned bipolar region and has remained stable. There are a total of six numbered sunspots, and three further new regions rotating onto it. A CME was produced by a C5.8 flare from AR3213 at 07/1232 UTC, but has been assessed as likely passing over the Earth's orbit on the 11th. No other Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Solar winds are generally elevated with Earth in the fast wind from coronal holes 74 and 75. Observed speeds at L1 were generally 500-550 km/s, but increased to 560-600km/s around 08/0700 UTC. The density of the solar wind has been at or below average. Total IMF strength, Bt, was Weak to briefly Moderate, with a peak value of 11nT around 08/0730 UTC. The north-south component Bz, was variable, but more generally southward directed ranging -8nT to +8 nT. Phi angle was mainly negative (towards the Sun). Geomagnetic activity was Quiet to Active (Kp 2-4).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at Background levels throughout. The high energy electron flux (greater than 2MeV) measured by GOES-16 was at Background to Moderate, peaking 605 pfu at 08/1050 UTC. The associated 24-hour electron fluence was below the Active level, but on a rising trend, with the observed fluence at 08/0000 UTC being 7.93e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with a slight chance of High levels being reached, mainly owing to the developing sunspots in the northern hemisphere, as well as further regions expected to rotate onto the disc during the period.

Solar Wind / Geomagnetic Activity: CMEs which left the Sun on the 4th, 5th and 7th, while forecast to miss the Earth, give a low chance of glancing interactions between days 1-4 (8th-11th). Otherwise, ongoing elevated solar winds due to the fast wind enhancement from CH74 and CH75 are forecast to gradually ease, with no other coronal hole sourced enhancements expected. Mainly Quiet to Unsettled geomagnetic activity is expected with a chance of Active intervals. There is a very slight chance of G1/Minor storms.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of rising in response to any significant flares. High energy electron flux is expected to be mainly Moderate, with a chance of reaching High levels, before declining towards background later by day 4 (11th). The associated 24 hour fluence is expected to stay below the Active threshold (1e8 integrated pfu), but with a chance of rising above, mainly day 2 (9^{th}).

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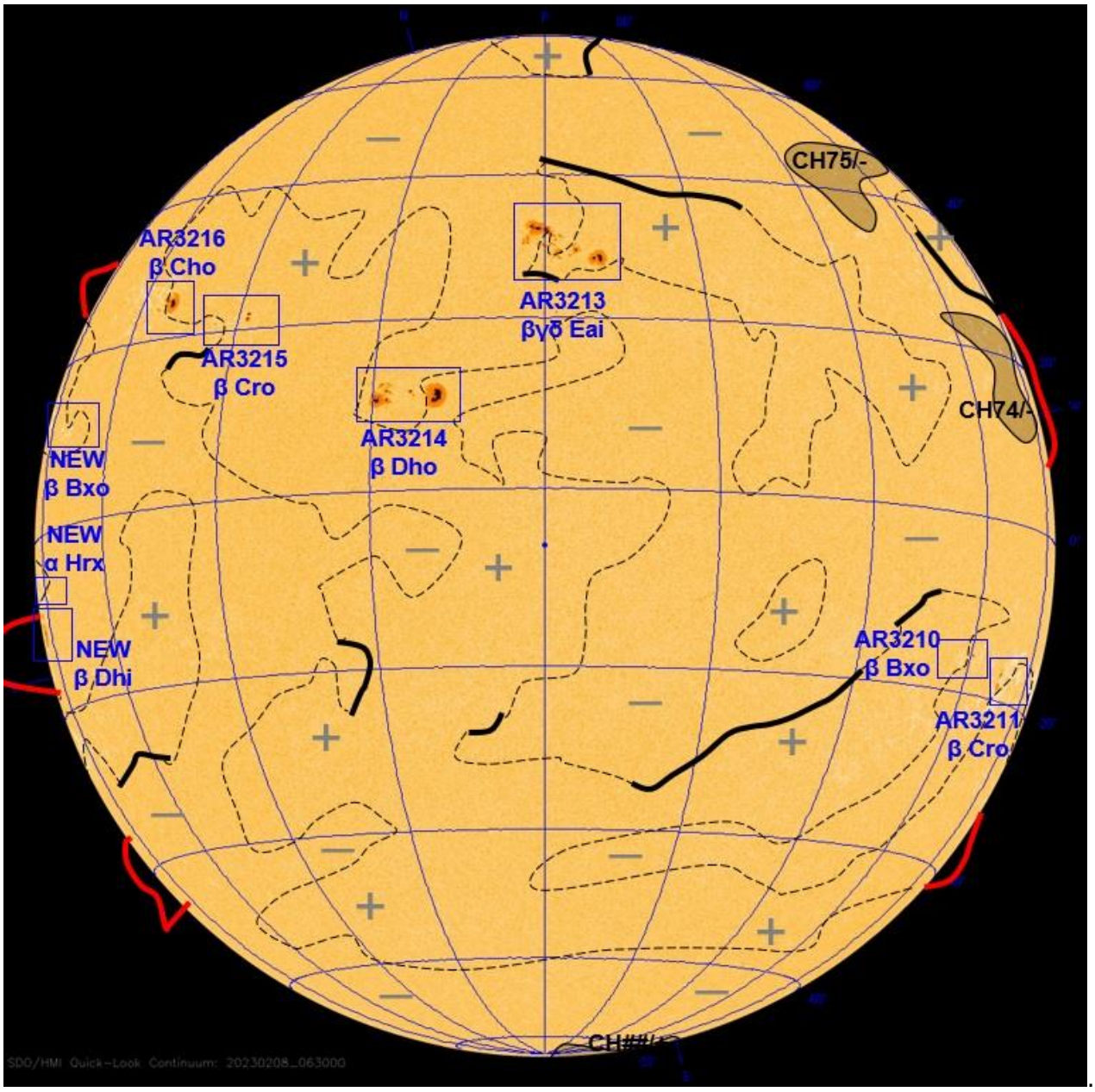
Figure 1. Solar Analysis Valid *.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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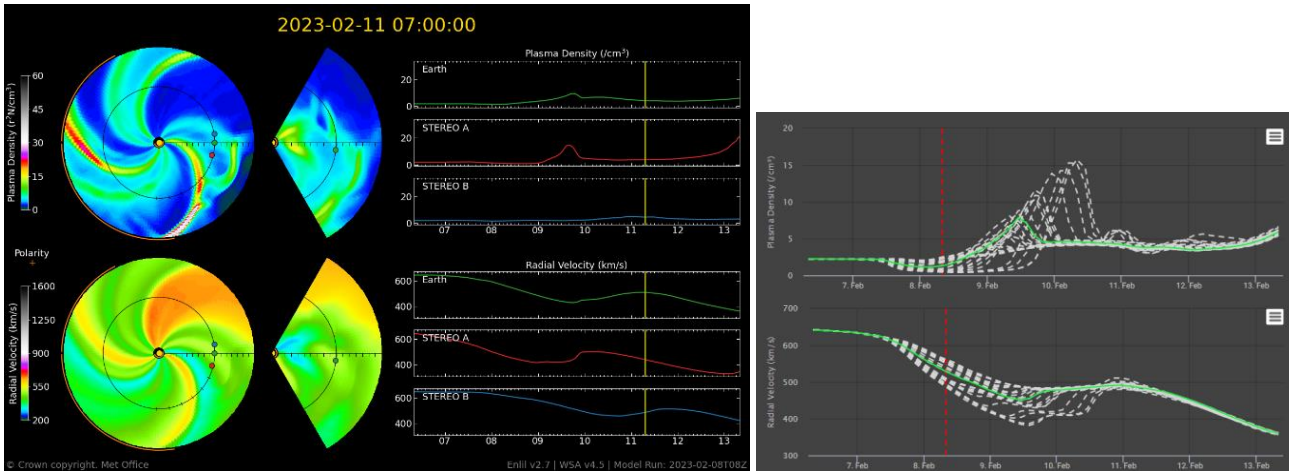
Geomagnetic Storms:

A number of CMEs are expected to miss, but pass close to Earth over the coming several days. These left the Sun on the 4th, 5th and 7th and given some uncertainty in their analysis, may give some peripheral interactions between Days 1-4 (8th-11th). Confidence is reduced further due to enlil currently over estimating the strength of the current fast wind environment. This is due to Earth moving through the fast wind originating from coronal holes 74 and 75. These solar winds are expected to ease through the period, with no further enhancement expected.

Mainly Quiet to Unsettled geomagnetic activity is expected, however given current fast winds and the low confidence CME outlook, Active intervals are possible on all days. There is a very slight chance of G1/Minor Storm intervals at any time during the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: ENLIL showing CME passing above Earth on the 11th. Ensemble showing uncertainty with CME arrivals from 8th-11th.



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Radio Blackouts - X-Ray Flares:

Moderate activity is likely at times through the period, with a number of notable active regions on the disc. There are six numbered regions, and three further new regions rotating onto the disc.

The most notable region is AR3213 in the north-centre, which was the source of the impulsive M6.3 at 07/2307 UTC. This is a relatively complex and moderately sized region with two small delta spots, but with the potential for further development. AR3214 is a further large region in the northern hemisphere, but magnetically simple. The other region of interest is visible on the eastern limb, with significant magnetic looping evident on e.g. SDO aia-171. These are currently too close to the limb for an accurate assessment, but also add to the risk of notable flares.

These give a likelihood of further M-flares through the period, and a very slight chance of X-flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	50	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3a: GOES-16/18 X-ray flux

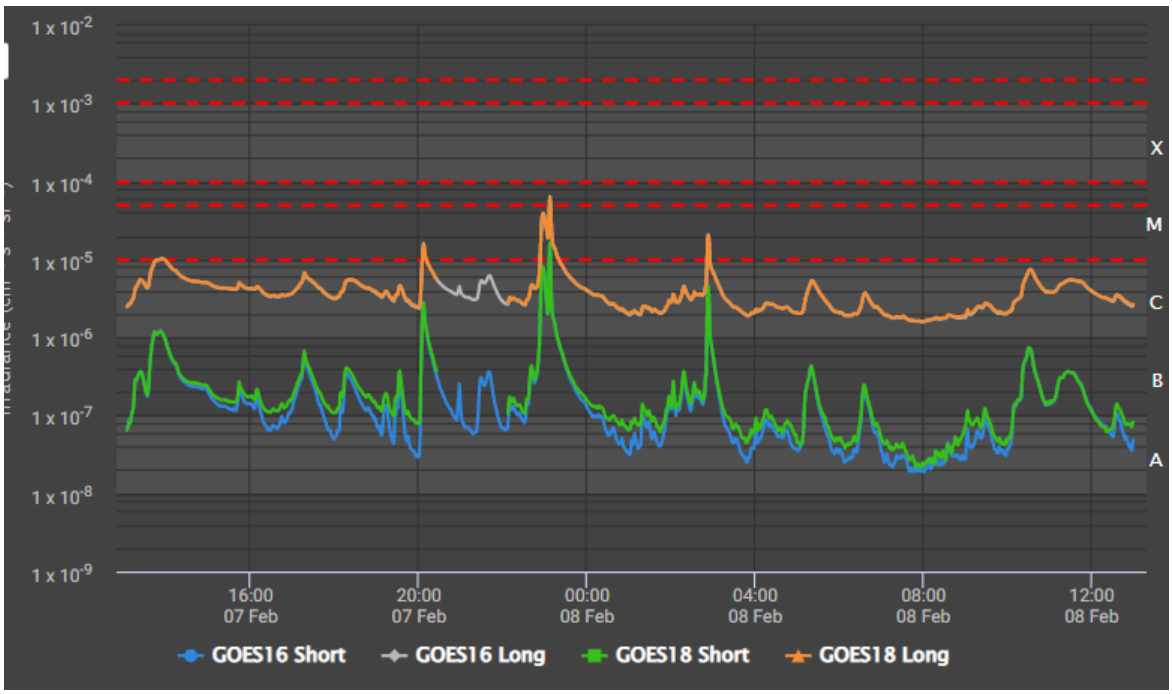

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Figure 3b: SDO aia-304 of M1.0 flare over E-limb (left), SDO aia-94 of M6.3 flare from AR3213 (right)

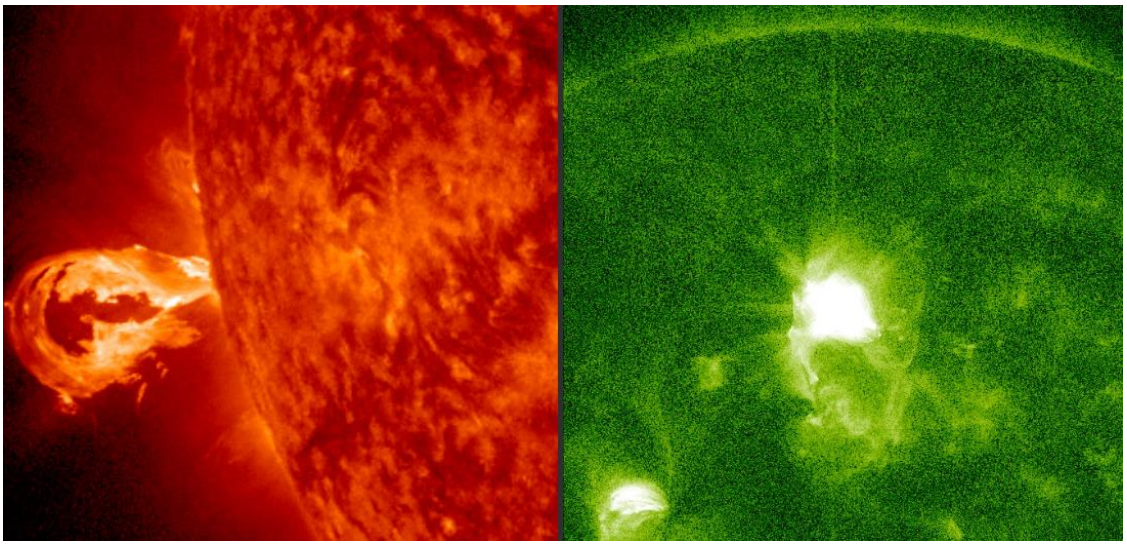
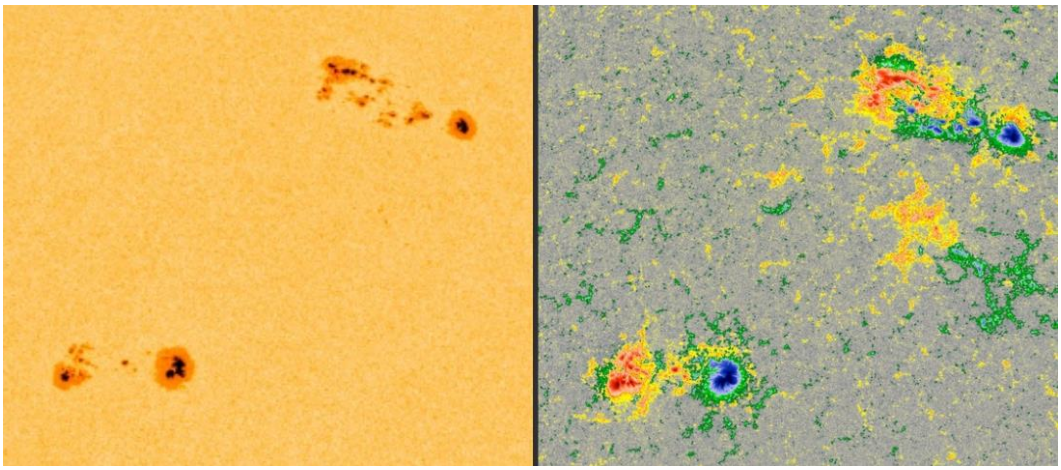


Figure 3c: SDO hmi intensitygram and magnetogram of two northern hemisphere spots.



Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux as observed by GOES16 is currently at background levels. No notable high energy proton response was observed from the M6.3 flare, however any further significant flares will give a slight chance of count rates increasing, with a very slight chance of reaching the S1 levels.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at mainly Moderate levels as a consequence of the recent slight enhancement to the geospace environment from the arrival of the fast wind from CH74 and CH75. This will bring a chance of reaching high at times, before falling again to mainly background levels by day 4 (11th).

The associated 24 hr fluence is likely to continue to rise, but staying below the Active threshold (1e8 integrated pfu). REFM is now indicating a clear rising trend, and giving good guidance at least until T+24. Beyond this period the model is less reliable due to its reliance on 27-day persistence which provides a poor comparison to recent conditions.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	30	20	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: >2MeV GOES-16 Electron Flux (top) and associated fluence (bottom) with REFM

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